The Open University of Sri Lanka
Faculty of Engineering Technology

Study Programme	:	Bachelor of Technology Honours in Engineering
Name of the Examination	:	Final Examination
Course Code and Title	:	**MEX5270 Power Electronics and Motor Drives**
Academic Year	:	2016/2017
Date	:	05th of December 2017
Time	:	1.30pm – 04.30pm
Duration	:	3 hours

General instructions

1. Read the instruction carefully before answering the questions
2. This paper consists of 8 questions. All questions carry equal marks.
3. Answer **any 5 questions only.**

Question 01:

a) A full wave rectifier is used to charge a 24V battery as shown in the Fig.Q1. Find the following:

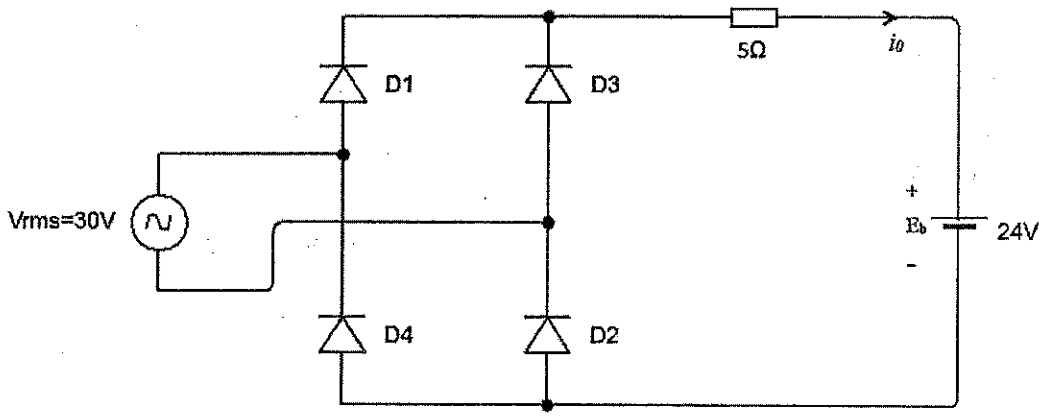


Fig.Q1

i. Power supplied to the battery,

ii. Gross output power of source,

iii. Input *p.f* and

iv. Efficiency. (13 Marks)

b) A 1000MW, double circuit, 3-phase ac transmission system is to be replaced by a HVDC transmission line with converter and inverter plants at the sending and the receiving ends respectively. Compare the transmission capability of the HVDC system with the old ac system. (Hint: consider the same percentage loss and the same insulation level for both the cases.) (7 marks)

Question 02:

For the transistor switch as shown in Fig.Q2, the current fall time during turn-off switching is 1.5μs. The on-state current is 20A. Assume that the load inductance is large and therefore, the load current is constant. Further, it can be assumed that the transistor current falls linearly during the turn-off switching transition.

a) Estimate suitable values for the snubber capacitance C and the snubber resistance R that will ensure the following.
   i. The voltage rise across the transistor will not exceed 100V at the instant when current falls to zero. (4 Marks)
   ii. The peak discharge current of the capacitor at turn-on switching should be limited to 8A. (2 Marks)

b) Determine the snubber power loss at a switching frequency of 10kHz for the chosen snubber circuit parameters. (4 marks)

c) Calculate the average switching power loss across the transistor during turn-off transition at a switching frequency of 10kHz. (4 marks)

d) Determine the time at which the collector power dissipation during turn-off switching transition will be maximum and hence calculate the peak power dissipation. (4 marks)

e) If the snubber circuit is not included, how much power the peak collector dissipates during turn-off transition?
   Compare it with that of the determined value in(d). (2 Marks)

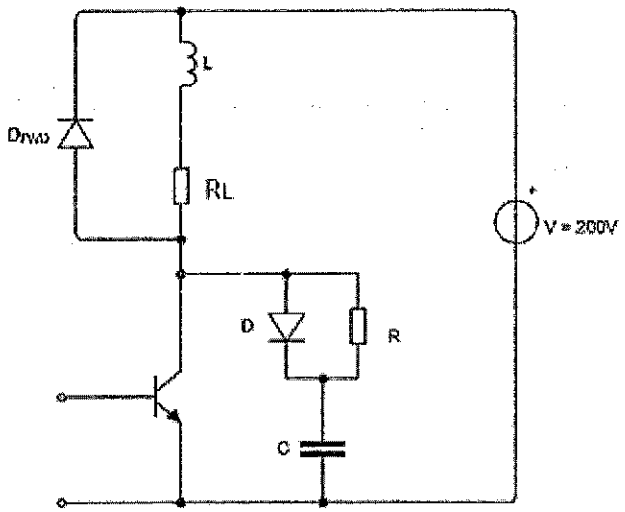


Fig.Q2

Question 03:

a) For a single-phase diode bridge rectifier circuit as shown in Fig.Q3, sketch the waveforms for the output voltage, V_d, the voltage drop across the inductor, v_L and the voltage drop across diode D_2, v_{d2}. (5 marks)

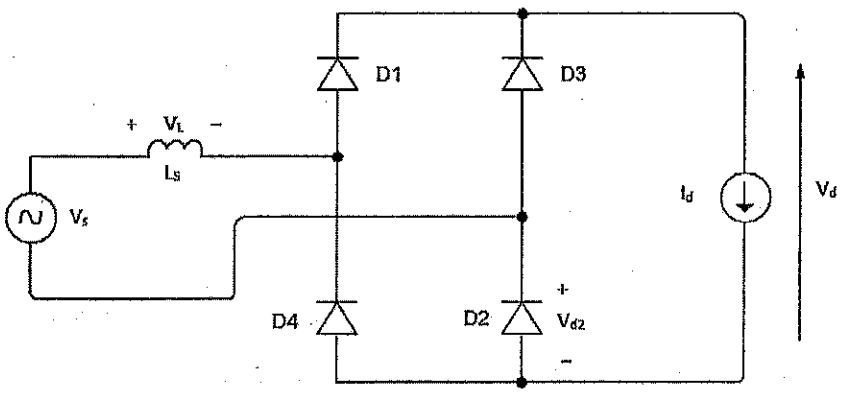


Fig.Q3

b) A full-wave controlled converter operating as an inverter is used to transfer power from a wind generator to a single-phase 240V rms, 50Hz ac supply. The generator produces a dc output of 150V and is rated at 5000W. The equivalent resistance in the generator circuit is 0.6Ω.

i. Determine the converter delay angle for rated generator output power. (4 marks)

ii. Assuming the thyristors to be ideal, determine the power absorbed by the ac system and the losses in the equivalent resistance. (3 marks)

iii. Assume that the delay angle for the thyristors remain the same as in (i) and the thyristors are non-ideal i.e voltage drop across each conducting thyristor is 1V. Determine the power loss in the thyristor converter and hence the power delivered to the ac source. (8 marks)

Question 04:

a) For a buck converter as shown in Fig.Q4, show that the minimum inductance required to keep the load current in continuous mode conduction is given by

$$L_{min} = \frac{(1-D)R}{2f}$$

Where D = Duty cycle of the switch, R = load resistance and f = switching frequency (8 marks)

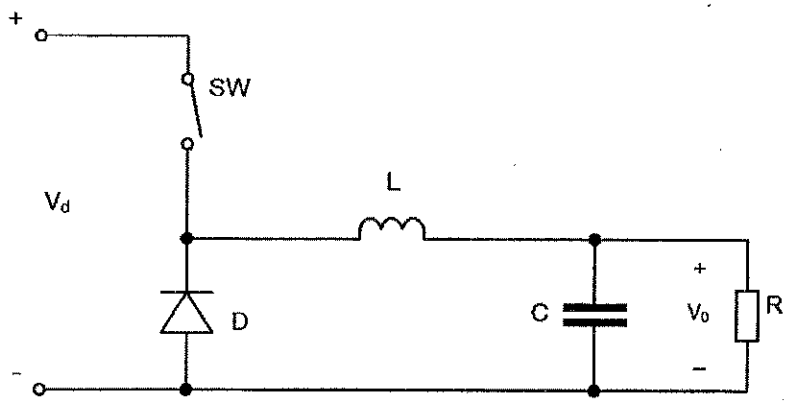


Fig.Q4

b) A buck converter as shown in Fig.Q4 has an input voltage that varies between 50 and 60V. The load power varies between 75 and 125 W. The output voltage is maintained constant at 20V under all operating conditions by varying the duty cycle of the switch. If the switching frequency is 20 kHz, determine the minimum inductance required to keep the load current continuous under all possible operating conditions. Calculate the corresponding minimum current for the worst-case condition. (8 marks)

c) If the capacitor used in Fig.Q4 has a value of 100μF then calculate the worst-case peak-to-peak ripple voltage in the output. (4 marks)

Question 05:

a) For the PWM voltage waveform shown in Fig.Q5, prove that the rms value of the total harmonic voltage, V_H, is given by

$$V_H = \sqrt{DV^2 - \frac{8V^2}{\pi^2} sin^2 \frac{1}{2} D\pi}$$ (6 marks)

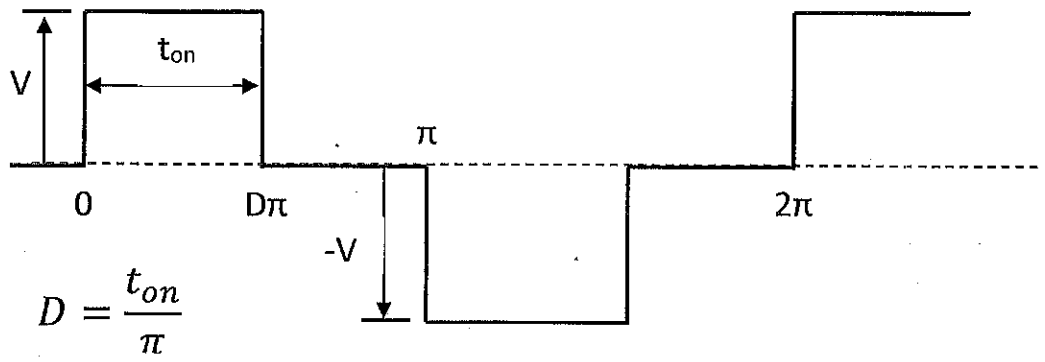


Fig.Q5

b) Determine the duty cycle D, for a full-bridge inverter with a dc source of 125V to produce an output voltage 100V at the fundamental frequency. Use the PWM switching scheme as shown in Fig.Q5. (4 marks)

c) Design an inverter which has a PWM output across an R-L series load with R = 14Ω and L = 28mH. The fundamental output voltage must be 120V rms at 50Hz and the total harmonic distortion (THD) of the load current must be less than 8%. Assume that the amplitude modulation ratio, m_a is 0.9 and the total harmonic content of the load current is the same as the dominant harmonic at carrier frequency.

Specify the dc input voltage and the switching frequency of the carrier wave.

(10 marks)

Question 06:

a) Explain the principle of operation of an inverter. (4 marks)

b) How are inverters classified? (4 marks)

c) Compare the advantages and disadvantages of half-bridge and full bridge inverters. (4 marks)

d) Explain the various performance parameters of an inverter. (4 marks)

e) What is the advantage of eliminating low-frequency harmonics from the output voltage of an inverter? (4 marks)

Question 07:

a) Explain the type A, B, C and D choppers. (8 marks)

b) A 220Vdc shunt motor drives a constant torque load at 1500rpm and draws 20A. when the same motor is fed from a chopper operating at $\alpha = 0.6$, then find the following quantities:

i. Speed of the motor.
ii. Average current.
iii. Maximum and minimum values of armature current.
iv. Peak to peak ripple.
v. Torque.
vi. Additional inductance required to limit the ripple to 10A.

(12 marks)

Question 08:

a) A single-phase ac voltage controller (shown in Fig.Q8) is operated with unequal firing angles for the two thyristors (firing angle α_1 for thyristor S_1 and α_2 for thyristor S_2 respectively)

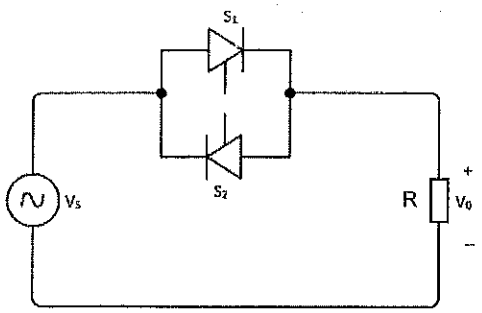


Fig.Q8

Show that the rms load voltage is

$$V_{0,rms} = \frac{V_m}{\sqrt{2}}\sqrt{1 - \frac{\alpha_1+\alpha_2}{2\pi} + \frac{\sin 2\alpha_1+\sin 2\alpha_2}{4\pi}}$$

where V_m is the peak ac input voltage (8 marks)

b) Assume that the thyristor S_2 of the ac voltage controller (shown in Fig.Q8) is replaced with a diode and the thyristor S_1 is operated with a firing angle of α.

i. Show that the rms load voltage is given by

$$V_{0,rms} = \frac{V_m}{\sqrt{2}}\sqrt{1 - \frac{\alpha}{2\pi} + \frac{\sin 2\alpha}{4\pi}}$$

(5 marks)

ii. Determine the range of rms voltage across the load. (4 marks)

c) Give comments if load (R) is replaced by a **ceiling fan.** (3 marks)